Appendix A – Test Protocol

Ship's Ballast Discharge Mixing Zone Benchmark Dye Tracer Test

Prepared for

Vitamar, LLC
Germantown, Tenneesse

File No. 03104
30 January 2004

GLOSTEN
The Glosten Associates, Incorporated

Consulting Engineers Serving the Marine Community

600 Mutual Life Building • 605 First Avenue
Seattle Washington 98104-2224
Phone: (206) 624-7850 • Fax: (206) 682-9117

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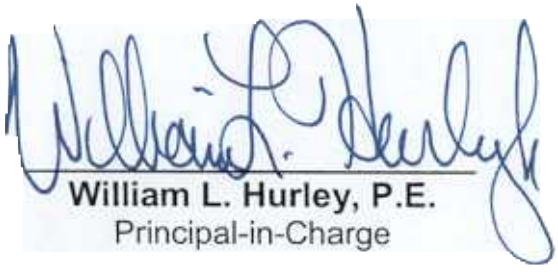
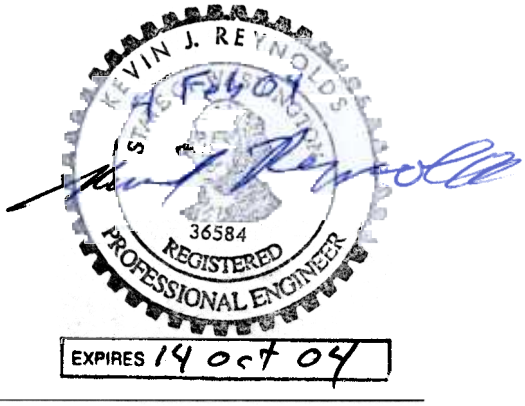


William L. Hurley, P.E.
Principal-in-Charge



Kevin J. Reynolds, P.E.
Project Engineer

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600 Mutual Life Building • 605 First Avenue
Seattle Washington 98104-2224
Phone: (206) 624-7850 • Fax: (206) 682-9117
E-mail: email@glosten.com

APPENDIX A – TEST PROTOCOL

SHIP'S BALLAST DISCHARGE MIXING ZONE BENCHMARK DYE TRACER TEST

This test protocol has been prepared for use by the vessel crew and the testing team in the field, and submittal to regulatory agencies. This protocol is a stand alone document, and is Appendix A of the testing report.

A. Dye Test Particulars (Attachment 1)

Attachment 1 provides details of the planned test. Included are details on the vessel, locations, testing dates, dye and investigators.

B. Testing Equipment Overview

1) Dye Concentration Measurement Instrumentation

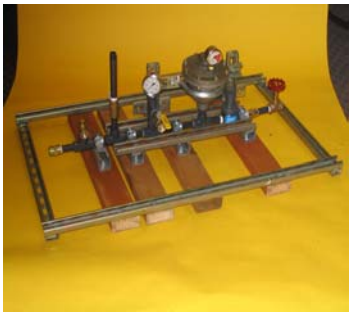
Instrumentation of the discharge is to be made with YSI Incorporated instruments. A 650 multiparameter display system logger is used to drive the 600 optical monitoring system sonde. The sonde is outfitted with conductivity, temperature and rhodamine WT probes. This is attached to a 75 foot extension cable. The logger is waterproof, rated to IP-67. The sonde is suitable for depths to 200 feet. See *Vessel Prearrival* for information on hazardous zone considerations.

The sonde provides a range of 0 – 200 parts per billion (ug/L) of rhodamine. It has an accuracy of +/-5% of reading, or +/-1 ug/L which ever is greater. It has a resolution of 0.1 ug/L.

YSI 650 Multiparameter Display System, YSI 600 Optical Monitoring System sonde, and the YSI 6130 rhodamine sensor.

2) Dye Injection Equipment

The dye injection equipment consists of mobile, skid mounted assemblies, suitable for rapid deployment on board a vessel. All equipment meets the hazardous zone requirements of the US Coast Guard, specifically Class 1, Division 1, hazardous locations as defined by National Electric Code Article 504. This equipment is capable of metering between 0.5 and 20 gallons per hour of tracer dye into the ballast main. A backpressure valve maintains constant system pressure to ensure even metering through system fluctuations. An adjustable relief valve on the discharge of the pump protects the ballast piping from over pressurization. All connections are rated to 300 pounds per square inch, maximum setting of the relief valve. The components are shown below.


Dosing tank and tracer dye transport container, Discharge manifold with pulsation dampener, Calibration tube and suction manifold.


Pump assembly with explosion-proof disconnect, 200 foot armored cable (one of two) with explosion-proof connector.

C. Dye Preparation:

To support rapid deployment on board the vessel, the dye batch should be mixed prior to deployment. A single final dilution of the dye should be made on board the vessel with seawater. This will assure near neutrally buoyant tracer dye entrainment into the ballast system. **Attachment 2** details the tracer dye dilution process.

The dye concentration measuring instrumentation is to be calibrated for both rhodamine WT, and conductivity within 24 hours of deployment as per YSI instructions. **Attachment 2** provides a calibration log.

D. Vessel Prearrival:

The vessel should arrive under the following conditions:

- Ballast tank status. One pair of ballast tanks should be empty. These tanks should be of a capacity such that the ballast system can be regulated to discharge these tanks when full in not less than 2 hours. The vessel should be loaded/ballasted in such a manner that this tank pair can be filled and then discharged without significant counter ballasting or other operations required.

- Ballast tank access. Each of the two ballast tanks should have two separate access locations to verify the dosing concentration. Each of these accesses should provide a means of 'sounding' the tanks through substantially their full height, with a 2" diameter probe. Suitable means such as hatches or manhole covers should be removed prior to testing day.

- Ballast system. There should be a single fitting (1/4" or larger) available for injecting dye into the suction main (preferred) or discharge main. This connection will be plumbed with gear brought aboard for this testing, and injected with dye at a rate of less than 20 gallons per hour, while the ballast tanks are being filled.

- Electrical, dosing equipment. The testing equipment runs on 120 Vac, 1 phase, 60 Hertz, with a full load draw of 5.8 amps. A standard three prong outlet supplied by at least a 15 amp breaker in a safe location is needed to support this equipment. The test equipment is also outfitted for a 3 prong explosion proof outlet suitable for connection to a mating connection in a hazardous zone. The testing equipment has 2 x 200 feet of armored cable. All electrical dosing gear is manufactured and assembled suitable for Class 1, Division 1 locations.

- Electrical, testing equipment. A battery powered probe and logger is used to verify the dye concentration of the ballast water after dosing. This unit has not been tested for use in Class 1, Division 1 locations. However, we have used this probe and logger in Class 1, Division 1 locations on vessels where a Class 3 hot work permit has been issued. We need to know if we can use the probe and logger in way of the ballast tank access. If not, other less advantageous arrangements can be made. To assist this decision, please consider the following:

- The National Electric Code Article 504, referred to by Code of Federal Regulations, allows use of certain equipment of low power generation in Class 1, Division 1 locations without being listed as suitable for these locations. The criteria for this states "… does not generate more than 1.5 volts, 100 milliamps, and 25 milliwatts …"

- The logger, YSI model 650 MDS, runs on 50.5 milliamps, and is powered at 6 volts. The logger has an IP67 enclosure (Dust proof, protected from temporary immersion in water 1 meter deep for 30 minutes).

- The probe, YSI model 600 OMS-0, is powered by the logger, and is rated to 90 meters immersion in water.

- Information. The following information is requested to assist equipment set-up and analysis of results:

  - Ballast tank pair capacity,

  - Ballast system expected flow rate at test conditions,

  - Ballast overboard, detailed construction drawing (size, orientation, schedule),

  - Ballast overboard position relative to vessel hull, and relative to expected waterline at test conditions,

  - Ballast connection position in system, size, and fitting type (i.e. 1-1/4" NPT female coupling).

E. Dosing Tanks (5 – 6 Hours):

Dosing of the tanks is achieved by metering in dye while an initially empty pair of tanks are being filled. This may be conducted at any time before the discharge monitoring event. This pair need be filled only until there is at least two hours of discharge available.

- Set-up (90 minutes): Place four equipment pallets on board. Connect dye feed tank, suction and discharge manifolds, discharge connection to ballast system. Make electrical connection. Discuss plan with vessel operators.

- Dose tank pair (depends on system, estimate 3 hours): Tank pair is to be filled as per standard vessel practice, allowing only the filling of this tank pair. No other tanks may be filled at this time. It is acceptable to stop filling this tank pair, perform other ballast operations, and then resume filling tank pair. While the tank pair is being filled, the dosing system will meter dye into the ballast main on a continuous basis, specifically matching the ballasting rate. Tank pair only need be filled enough to allow a minimum of two hours of discharge. The metering rates and log sheets are given in **Attachment 2**.

- It is important that the injection piping is purged with the tracer dye prior to starting filling the tank pair. **Attachment 2** provides guidance on volumes to be displaced. Additionally, it is important that the ballast main is purged with traced dye water prior to filling. As such, it is desirable that the ballast system be aligned to take suction from the sea, and discharge to the sea during this purging period.

- Verify dye concentration/dosing system breakdown (90 minutes): These two operations will take place at the same time. Once the tank pair is full with dyed ballast water, they need to be sampled with the electrical testing gear through the ballast tank accesses. Two vertical profiles will be taken. Readings of each profile are to be recorded in the log every ten feet, detailed in **Attachment 2**. The first objective is to assure that there is an even distribution of the dye through the tank. The second objective is to identify the start concentration of the ballast water. This start concentration, when compared to concentrations upon discharge will determine the dilution ratios. Four equipment pallets to be taken off board.

F. Discharge Monitoring (3 – 4 Hours):

Discharge monitoring is the process of measuring dye concentrations in the sea as ballast water is discharged overboard. At the overboard, a three person team in a dingy will trace a radial pattern measuring dye concentrations in the sea. On board the vessel, a single team member will provide communications with the dingy. The following outlines this process:

- Set-up (performed during dosing tanks event – 60 minutes): Measurement of start event current and wind. Coordination of placing team member aboard, and establishing vessel communications. Place magnets on vessel hull for measurement of radial tracing pattern. Mark hull in way of overboard, and 50 feet forward and aft with non-permanent paint or chalk. Coordinate discharge event start.

- Discharge sampling (depends on system, minimum 2 hours, estimate 3 hours): While vessel is discharging, team will use a line attached to vessel by means of a magnet to trace a radial pattern around the vessel ballast overboard. A log sheet for this exercise is provided in **Attachment 2**.
    - It is not known how long it will take for the discharge plume to reach steady state. Twenty minutes after the discharge has started, the team will assume steady state and begin readings, starting at the point furthest from the end-of-pipe.
    - It is not known if the plume will be a cohesive jet, a diffusing flow, or both within the 50 feet zone from the end-of-pipe. As such, the testing team will rely on two strategies:
        - A **methodical sweep** of the area will canvas the 50 foot radial zone. The first sweep at 50 feet will be made by performing a single vertical profile directly outboard of the discharge.

Adjacency to the overboard will be confirmed through use of a laser range finder. At the depth of highest concentration the dingy will then be maneuvered forward relative to the vessel position. If the concentration level rises, then the dingy will stop at the point of highest concentration and conduct a vertical profile. If the concentration falls, then the dingy will be swept forward until a reading of 8 ug/L is reached, and then a profile performed. This process is then repeated by maneuvering the dingy aft. Subsequent sweeps are to be made at 35, 25, 20, 15, and 10 feet.

- As the methodical sweep is made, it is possible that a transect registers no or very low readings (less than 4 ug/L). In this case, if a relatively high reading in this field of low readings is detected, then a **tracking run** will be conducted as follows:
  - Perform radial sweep in vicinity, locating high radial reading,
  - Perform vertical sweep at high radial reading position, locating vertical high reading,
  - Repeat radial sweep

- Visual reviews of wider dispersion will be made from the vessel bridge. These will be followed up with testing of concentrations of visual sites by the dingy.

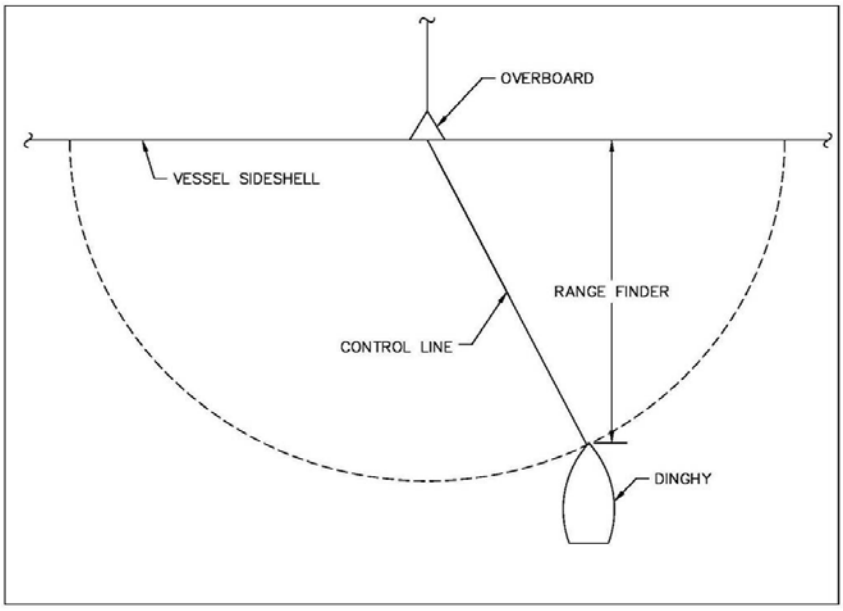


Diagram showing use of control line to set radial distance from end-of-pipe.

Control line use in field, Dosing equipment deployed on product carrier.

- In the event of a failure of the rhodamine WT probe, NISKIN bottle samples will be drawn. A string of three ½ liter bottles will be used to gain samples. At 10, 30 and 50 foot depths samples will be drawn at outboard, 45 degree forward, and 45 degree aft positions from the overboard, at 50, 30, 20, and 10 feet from the overboard.
- Environmental data will be gained by the setting of a current drogue by the dingy team before and after the discharge event. In addition, environmental data will be gained from the vessel navigation suite and crew. See **Attachment 2**.
- Sampling breakdown (vessel interaction – 30 minutes, after vessel departs – 30 minutes): Pick-up person on board the vessel. Measurement of end event current and wind.

ATTACHMENT 1
DYE TEST PARTICULARS

Vessel	Name:	Groton
	Owner:	United States Shipping, LLC
	Particulars:	Oil Tank Barge, Single Hull, US Flag
		48,067 long ton deadweight
		691'-02" length overall
		375,145 barrel cargo capacity
Location:		Washington State, Puget Sound
	Primary:	Port of Port Angeles, Anchorage
	Secondary:	Anacortes, March's Point, Refinery Docks
Testing Date:		Three tests maximum between February and June 2004, data below is for one test.
Investigator:		The Glosten Associates, Inc., Seattle, Washington
	Primary:	Kevin J. Reynolds
	Secondary:	Maurice W. McCarthy
Dye,	Generic Name:	Rhodamine WT
	Trade Name:	Intracid Rhodamine WT Liquid, A34517L100 Tracer Dye
	Transport/Injection:	1-1/4% concentration, premixed for testing event
		0-0.31% concentration, prior to entrainment into ballast stream
	Vessel Discharge:	200 uG/L (parts per billion), entrained in ballast stream, end-of-pipe value, maximum concentration 1, 2
		2,000 metric tons per hour, maximum rate 1
		10,000 metric tons, maximum volume 1
		1.8 grams, maximum dye discharge 1

Note 1: Rate, volume, and dye discharge are based on Steam Tanker Tonsina particulars, and are listed here as maximums. Groton values may be less.

Note 2: Maximum concentration is end-of-pipe value, which does not consider dilution due to mixing upon discharge.

ATTACHMENT 2
LOG SHEETS

1. **Dye Dilution Prep Worksheet/ Meter Calibration Check**
2. **Dosing Pump Set Point Chart/ Total Rhodamine Wt Added**
3. **Dosing Pump Log Record**
4. **Tank Dye Concentration Readings**
5. **Radial Transect Log**
6. **Tracking Runs**
7. **Environmental Data Log**

DYE DILUTION PREP WORKSHEET

Dilution Step	Initial			Diluent		Working			
	Gal.	Sp.Gr.	uG/L	Gal.	Sp.Gr.	Gal.	uG/L	%	Sp.Gr
Intracid 20%	5	1.150	2.30E+08	0	0.000	5	2.30E+08	20	1.150
First Dilution	1	1.150	2.30E+08	3	1.000	4	5.75E+07	5	1.038
Second Dilution	4	1.038	5.75E+07	12	1.000	16	1.44E+07	1.25	1.009
---Final dilution with seawater, prior to injection									
Final Dilution	5	1.009	1.44E+07	15	1.025	20	3.59E+06	0.3125	1.021

* Fill out only highlighted cells in worksheet
** Gal. is Gallons
*** Entered data is ideal for dosing systems with 750 tons/hour capacity, and suitable up to 1,500 tons/hr.

Conversions

1 Gallon = x liters *3.78541*
1 Barrel = x liters *158.987*
1 metric ton = x liters *1000 volumetric (sea and fresh)*

METER CALIBRATION CHECK

Date/Signature	Test Performed	Notes
	2 Point Rhodamine WT	
	2 Point Conductivity	

* Calibration should be less than 24 hours prior to testing.

DOSING PUMP SET POINT CHART

Target Concentration (uG/L) **1.80E+02**
Tracer Solution (uG/L) **3.59E+06**

Ballast Pump Rate			Dose Pump Rate	
Ton/hr	Bbl/hr	Gal/min	Gal/hr	Gal/min
200	1,258	881	2.6	0.04
300	1,887	1,321	4.0	0.07
400	2,516	1,761	5.3	0.09
500	3,145	2,201	6.6	0.11
600	3,774	2,642	7.9	0.13
700	4,403	3,082	9.3	0.15
800	5,032	3,522	10.6	0.18
900	5,661	3,963	11.9	0.20
1,000	6,290	4,403	13.2	0.22
1,100	6,919	4,843	14.6	0.24
1,200	7,548	5,283	15.9	0.26
1,300	8,177	5,724	17.2	0.29
1,400	8,806	6,164	18.5	0.31
1,500	9,435	6,604	19.8	0.33

Purge Volumes				
diameter	0.25	0.50	1.00	inch
area	0.20	0.39	0.79	inch^2
length	100.00	100.00	100.00	feet
volume	235.50	471.00	942.00	inch^3
	1.02	2.04	4.08	gallons

TOTAL RHODAMINE WT ADDED

Target Concentration (uG/L) **1.80E+02**

Ballast Tank Capacity				Added
Tons	Bbls	Gallons	Liters	Grams
100	629	26,417	1.00E+05	-
200	1,258	52,834	2.00E+05	-
300	1,887	79,252	3.00E+05	-
400	2,516	105,669	4.00E+05	-
500	3,145	132,086	5.00E+05	-
600	3,774	158,503	6.00E+05	-
700	4,403	184,920	7.00E+05	-
800	5,032	211,338	8.00E+05	-
900	5,661	237,755	9.00E+05	-
1000	6,290	264,172	1.00E+06	-
1500	9,435	396,258	1.50E+06	-
2000	12,580	528,344	2.00E+06	-
2500	15,725	660,430	2.50E+06	-
3000	18,869	792,516	3.00E+06	-
3500	22,014	924,602	3.50E+06	-
4000	25,159	1,056,688	4.00E+06	-
4500	28,304	1,188,774	4.50E+06	-
5000	31,449	1,320,861	5.00E+06	-
5500	34,594	1,452,947	5.50E+06	-
6000	37,739	1,585,033	6.00E+06	-
7000	44,029	1,849,205	7.00E+06	-
8000	50,319	2,113,377	8.00E+06	-
9000	56,608	2,377,549	9.00E+06	-
10000	62,898	2,641,721	1.00E+07	-

DOSING PUMP LOG RECORD

Target Concentration (uG/L) 1.80E+02 **Test Date:**

Tracer Solution (uG/L) 3.59E+06

Time	Tanks Dosing	Ballast Pump Rate			Dose Pump Rate		Notes (Track dye quantities)
		Ton/hr	Bbl/hr	Gal/min	Gal/hr	Gal/min	

Tank Dye Concentration Readings

***Take two soundings for each tank after dosing ballast water. Readings at least every ten feet.**

Tank 1 ( ) Location 1 ( )		Tank 1 ( ) Location 2 ( )		Tank 2 ( ) Location 1 ( )		Tank 2 ( ) Location 2 ( )	
Level	**uG/L**	**Gallons**	**Liters**	**Level**	**uG/L**	**Gallons**	**Liters**
Average		Average		Average		Average	

Radial Transect Log (circle one) 50, 35, 25, 20, 15, 10 Foot

Step 5
At high concentration depth
Maneuver forward to 5 ug/L reading
If readings are too low, goto next transect
Get Aft profile

Step 4
At high concentration depth,
Maneuver aft to highest reading
If readings get lower, goto to Step 5
Get High profile

Step 1
Get Abeam profile

Step 2
At high concentration depth,
Maneuver forward to highest reading
If readings get lower, goto to Step 3
Get High profile

Step 3
At high concentration depth
Maneuver forward to 5 ug/L reading
If readings are too low, goto Step 4
Get Forward profile

	Aft	High (Aft)	Abeam	High (Fwd)	Forward
Start Laser Distance					
Start Time					
2 Ft Conductivity					
Rhodamine WT (uG/L)					
2 FT					
10 FT					
20 FT					
30 FT					
40 FT					
50 FT					
60 FT					
70 FT					
Stop Laser Distance					
Stop Time					
70 Ft Conductivity					
Notes:					

Tracking Runs

Tracking Run #

Radial Sweep 1		Time:		Distance from pipe:		
Depth	Low Reading Aft		High Reading		Low Reading Fwd	
Feet	Laser	ug/L	Laser	ug/L	Laser	ug/L
Vertical Sweep 1		Time:		Distance from pipe:		
Laser	Low Reading Up		High Reading		Low Reading Down	
Feet	Depth	ug/L	Depth	ug/L	Depth	ug/L
Radial Sweep 2		Time:		Distance from pipe:		
Depth	Low Reading Aft		High Reading		Low Reading Fwd	
Feet	Laser	ug/L	Laser	ug/L	Laser	ug/L

Tracking Run #

Radial Sweep 1		Time:		Distance from pipe:		
Depth	Low Reading Aft		High Reading		Low Reading Fwd	
Feet	Laser	ug/L	Laser	ug/L	Laser	ug/L
Vertical Sweep 1		Time:		Distance from pipe:		
Laser	Low Reading Up		High Reading		Low Reading Down	
Feet	Depth	ug/L	Depth	ug/L	Depth	ug/L
Radial Sweep 2		Time:		Distance from pipe:		
Depth	Low Reading Aft		High Reading		Low Reading Fwd	
Feet	Laser	ug/L	Laser	ug/L	Laser	ug/L

Tracking Run #

Radial Sweep 1		Time:		Distance from pipe:		
Depth	Low Reading Aft		High Reading		Low Reading Fwd	
Feet	Laser	ug/L	Laser	ug/L	Laser	ug/L
Vertical Sweep 1		Time:		Distance from pipe:		
Laser	Low Reading Up		High Reading		Low Reading Down	
Feet	Depth	ug/L	Depth	ug/L	Depth	ug/L
Radial Sweep 2		Time:		Distance from pipe:		
Depth	Low Reading Aft		High Reading		Low Reading Fwd	
Feet	Laser	ug/L	Laser	ug/L	Laser	ug/L

Environmental Data Log

Date:

Navigation Bridge Data	Time	Vessel		Current		Sea State	Wind Heading	Wave Heading
		Position	Heading	Direction	Heading			
Filling Start								
Filling Complete								
Discharge Start								
Plus 1 Hour								
Plus 2 Hours								
Plus 3 Hours								
Discharge Complete								

Testing Crew Data
20 Minute Test Prior to Discharge Event

Drogue Height	
Set Drogue Time	
Set Drogue Position	
Retrieve Drogue Time	
Retrieve Drogue Position	

Testing Crew Data
20 Minute Test Following Discharge Event

Drogue Height	
Set Drogue Time	
Set Drogue Position	
Retrieve Drogue Time	
Retrieve Drogue Position	